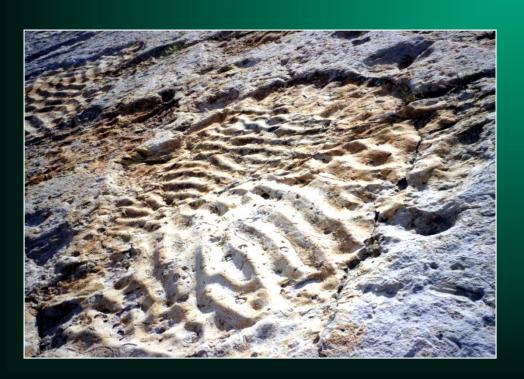
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Microbially induced sedimentary structures (MISS) – biosignatures for Mars exploration



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Definition of MISS:

"Microbially induced sedimentary structures are caused by benthic microorganisms interacting with sandy or muddy aquatic sediment leaving a trace behind"

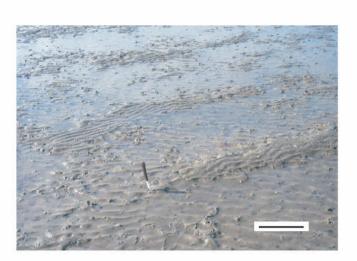




Worm burrow in fresh sediment

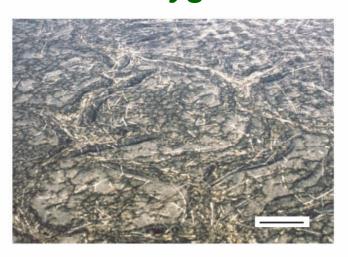
Fossil worm burrow in sedimentary rock

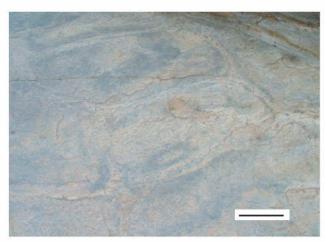
Multidirected ripple marks



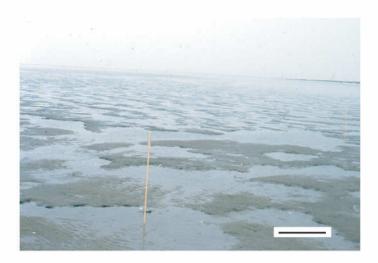


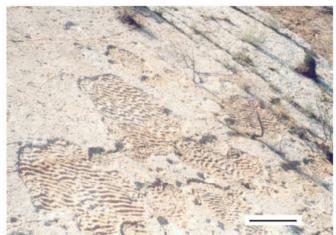
Polygonal oscillation cracks





Erosional remnants and pockets





Microbial mat chips





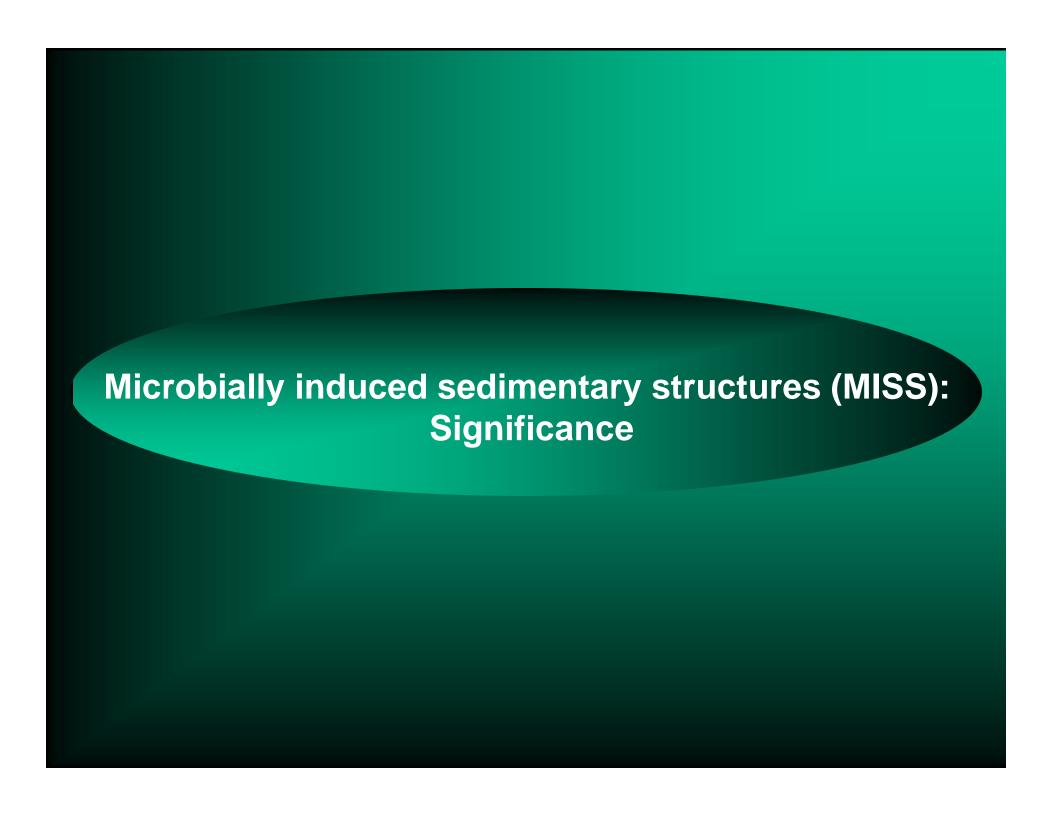
Hypothesis:

"Modern or ancient aquatic deposits on Mars include MISS"

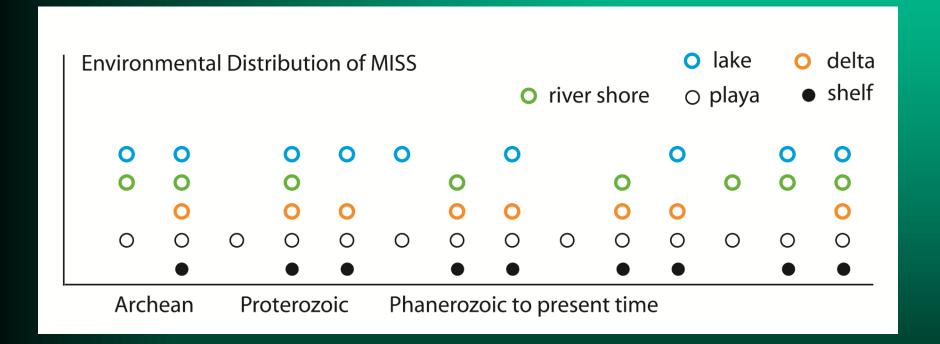
- On Earth, MISS occur in all aquatic deposits from 3.5 billion years ago until the present time
- Their morphology and environmental distribution has not changed over time

Content

- Microbially induced sedimentary structures (MISS): significance
- Biofilms and microbial mats formed by benthic microorganisms
- Interaction of benthic microorganisms with physical sediment dynamics and formation of MISS
- How to detect MISS on Mars (if they are there)



Distribution of MISS on Earth



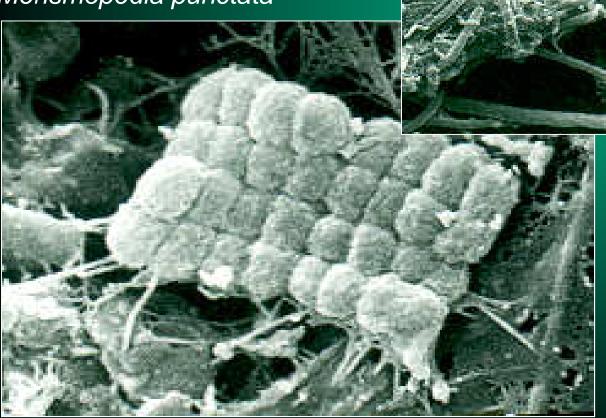
Benthic microorganisms forming biofilms and microbial mats in modern aquatic environments

Aquatic deposits are not 'sterile', but colonized by benthic microorganisms



modern cyanobacteria (SEM)

Merismopedia punctata



Microcoleus chthonoplastes

Microbenthos forms a

microbial mat





Interaction of microbenthos with physical sediment dynamics forms MISS

Physical sediment dynamics

Latency

physical sediment dynamics

Deposition

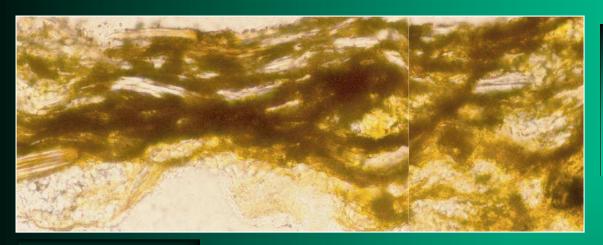
Erosion

Microbial response to physical sediment dynamics

Binding/Growth

Baffling, Trapping

Biostabilization



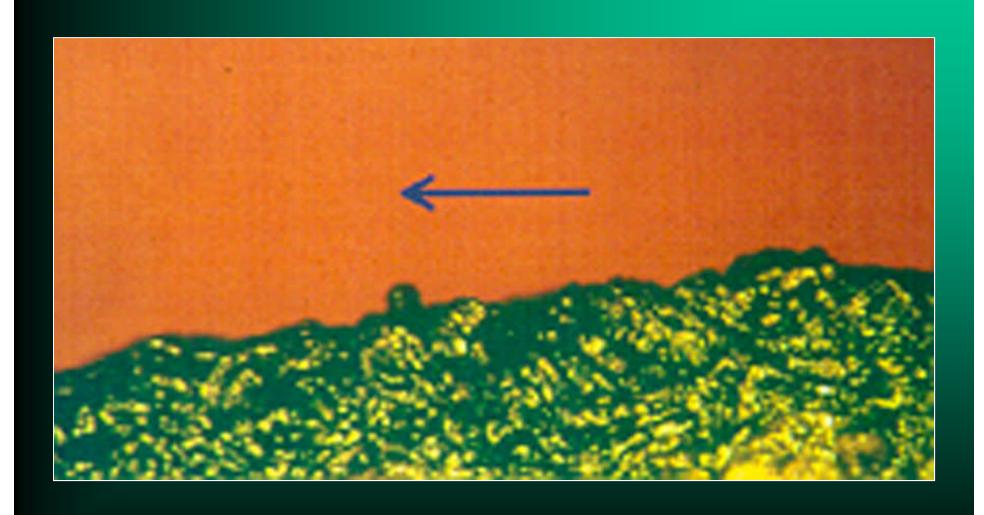
Microbenthos responds to latencies by...

... binding

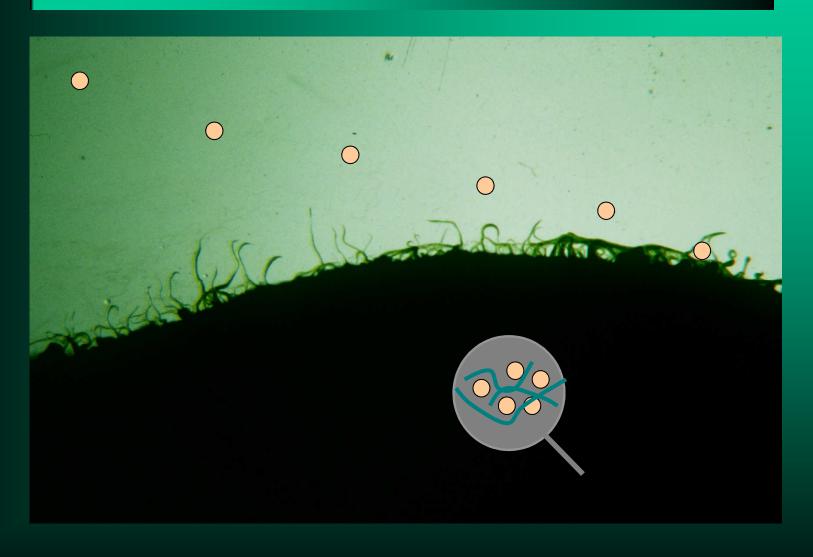


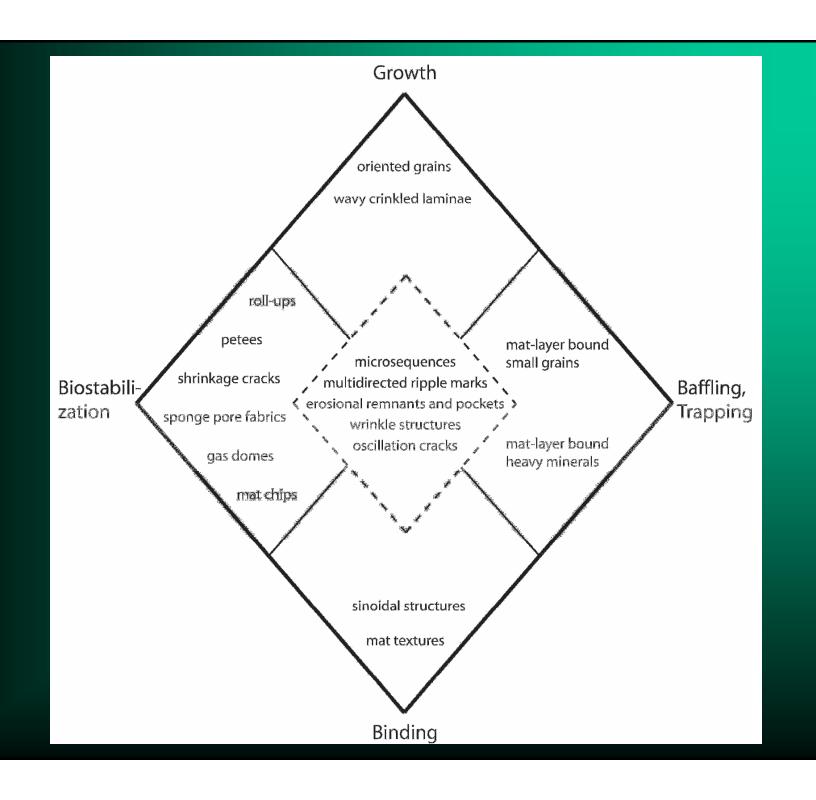
... and growth

Microbenthos responds to erosion by biostabilization



Microbenthos responds to deposition by baffling and trapping





...and on Mars?

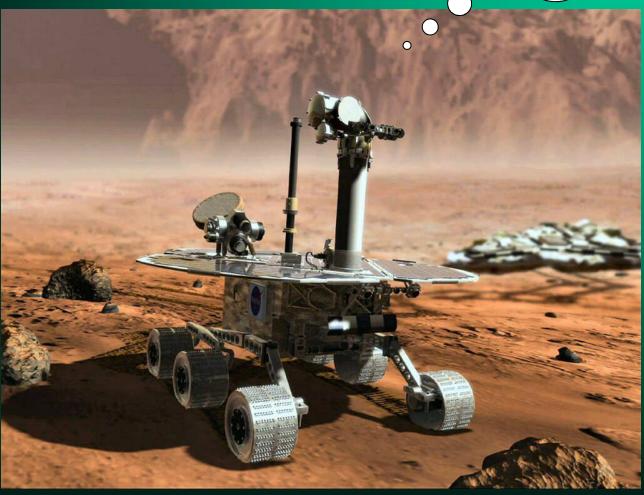


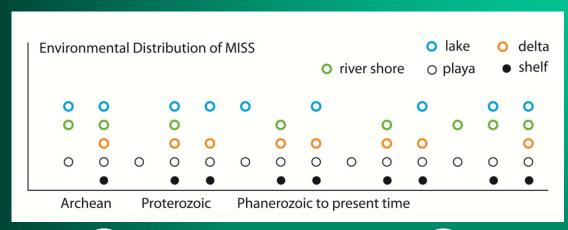
Photo: Nathalie Cabrol

Steps of MISS Detection:

Detection
Identification
Confirmation
Differentiation

Detection

Search for equivalent depositional settings on Mars





Detection



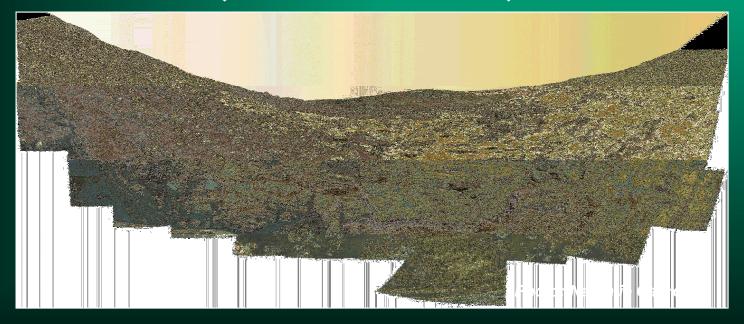
modern

ancient

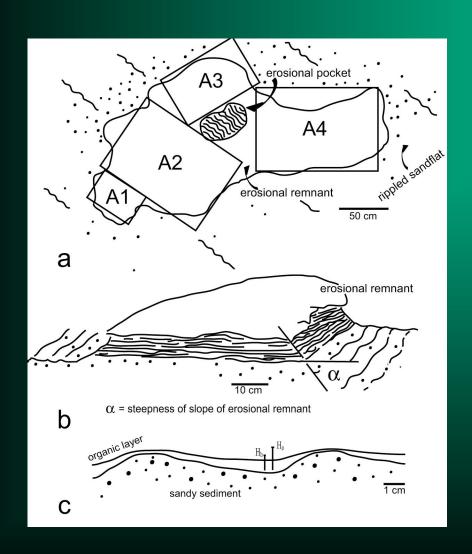








Identification



Quantification of Geometries and Dimensions

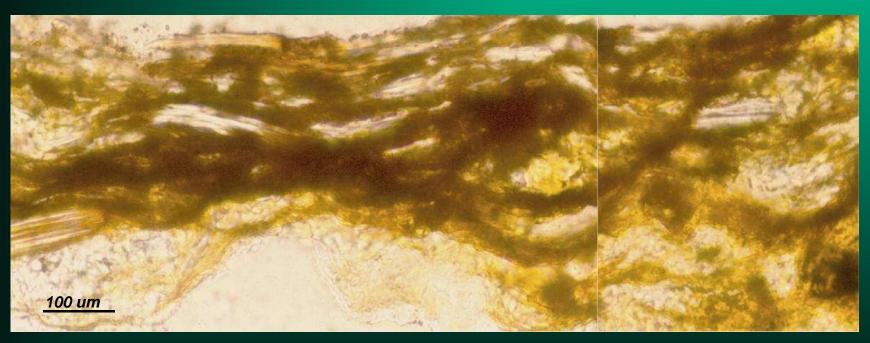
IA = Am/Ai

 $Is = sin \alpha$

IN = 1 - [(Hp - Hb) / Hp]

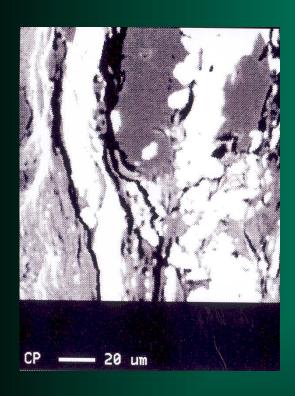
Confirmation

Close-ups:
Hand lens
Light microscopy
Statistical measurements
on various microtextures

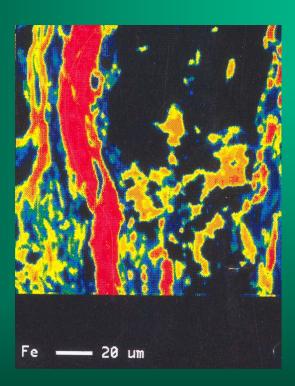


Confirmation

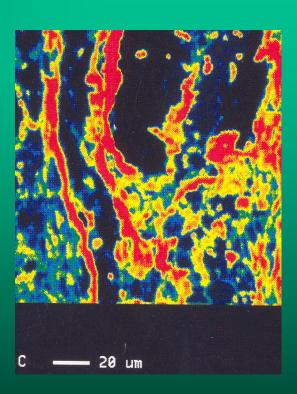
geochemical methods



Original Photo of Microstructures



Distribution of Iron Minerals



Distribution of Organic Carbon

Differentiation

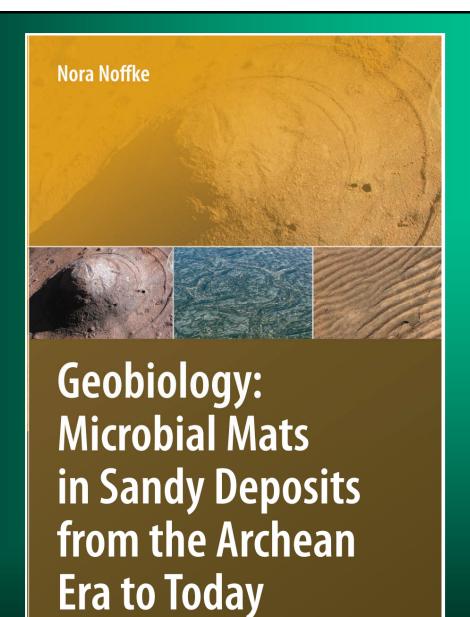


Conclusion

In aquatic deposits on Earth, the morphology of MISS and their environmental distribution has not changed since 3.5 billion years.

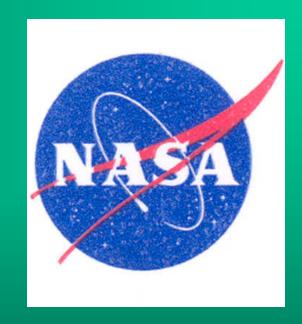
MISS range from kilometer scale to millimeter scale and can be detected easily on depositional surfaces and in vertical view on rock strata or fresh sediments.

MISS have a distinct morphology expressed in statistical indices; no transitional forms to abiotic structures exist.









Thank you!

questions or images: nnoffke@odu.edu